A New Engagement Model to Complete and Operate the National Ecological Observatory Network

Michael R. Kuhlman,[1] Henry W. Loescher[2,3], Richard Leonard,[1,2] Richard Farnsworth,[1,2] Todd E. Dawson,[4] and Eugene F. Kelly[2,5]

[1]Battelle, Columbus, Ohio 43201 USA

[2]National Ecological Observatory Network (NEON), Boulder, Colorado 80301 USA

[3]Institute of Alpine and Arctic Research (INSTAAR), University of Colorado, Boulder, Colorado 80301 USA

[4]Department of Integrative Biology, University of California – Berkeley, Berkeley, California 94720 USA

[5]Department of Soil and Crop Sciences, Colorado State University, Fort Collins, Colorado 80523 USA

Introduction

As the impacts of environmental change grow, there is a more urgent imperative to provide consistent, long-term ecological data for research and education for the societal benefit of the United States—that is, North America and elsewhere (Holdren et al. 2014, Peters et al. 2008, 2014, President's Council of Advisors on Science and Technology (PCAST) 2011; Collins et al. 2010). To meet these needs, the National Ecological Observatory Network (NEON) was conceived after more than a decade of planning and engagement with the ecological communities. NEON is novel by (1) adopting the cause-and-effect paradigm and (2) providing a robust scaling strategy to collect local, site-based information and scale this information to the region and continent, and from instantaneous-to-decadal temporal scales (Schimel et al. 2011, www.neonscience.org). NEON is designed to act as a single, coordinated continental-scale instrument to assess the ecological trends and environmental pulse of the nation. NEON's data products are intended to address the grand challenges for environmental science that the National Academy of Science has advocated—biodiversity, biogeochemistry, climate change, ecohydrology, invasive species, infectious disease, and land-use change (National Research Council (NRC) 2001).

Building a large-scale, distributed research infrastructure for the environmental science community such as NEON has never been attempted before, and its full potential has yet to be realized by the ecological community (Loescher et al. 2016). NEON has been under an extended period of public scrutiny of late (Office of Inspector General (OIG) 2014; Mervis 2015a, b, c). Engineers and scientists actually involved in the design and construction of a large-scale research infrastructure understand that it is a complex problem influenced by multiple opinions as to what it should be and why it should be built (Schimel and Keller 2015).

The National Ecological Observatory Network is the first large-scale infrastructure project that has been executed by the National Science Foundation's (NSF) BIO Directorate. Once the cost overruns and lack of timely corrective measures were identified by NSF, they took action, which included changing the NSF oversight structure as well as the NEON project's leadership and management.

It is important to note that during the NEON project's most recent assessment in December 2015, the NSF had the opportunity to end this project. Instead, with a commitment to the original vision, thought leaders in the ecological community and NSF leadership worked together to find a solution (e.g., Baron et al. 2015, Dawson et al. 2015). In the spring of 2016, NSF brought in Battelle as the new managing entity of NEON (replacing NEON, Inc.) to complete the construction and initial operations phase of the observatory and to address some of the shortcomings in community engagement. Here, we discuss the recent descoping and the NEON program's proposed approach moving forward.

Background

In 2011, the National Science Board (NSB) approved the expenditures to construct NEON and deemed it "transformative science." NSF support to construct the observatory is provided through the Major Research Equipment and Facilities Construction (MREFC) Program. The MREFC construction effort will be complete by the spring of 2018. In the interim, as NEON facilities are completed, they will transition to operational status through a commissioning process. Operations of the Observatory are anticipated to continue for 30 years and will be supported with Research and Related Activities (R&RA) funds from the BIO Directorate.

Addressing the recent descoping

As can happen during MREFC projects, NEON's construction had reached a stage where options for managing scope needed to be re-evaluated. The no cost overrun policy followed by NSF makes it likely that some level of descoping of NSF large facilities projects will occur as a result of unanticipated costs. Few MREFC projects have not experienced a descope. Faced with an estimated ~$80 million shortfall to complete NEON's construction, a group of external scientists representing the NEON, Inc., its Board, its Science, Technology, and Education Advisory Committee (STEAC), and outside experts were convened in the summer of 2015 to develop a scope management approach and to review options for meeting project costs and schedule.

Even though NEON's original science requirements and justification still hold true, other practicalities in implementing its design exerted their influence. NEON does not own any site, rather it contracts for site usage, and permitting constraints proved to be far more challenging than originally planned. For example, critical path permitting issues included: zoning for required tower height in urban environments, knitting a patchwork of urban sites together for organismal sampling, nutrient additions in streams, and failed permits after years of negotiation—all of which degraded NEON's ability to advance the project as originally envisioned within its budget and time constraints.

Collectively, the convened experts made a series of descoping recommendations that maintained the integrity of the program's core science design and its high-level science requirements. Those recommendations were intended to manage the project within its budget with the requisite no cost overrun. The descope process also allowed for the elimination of infrastructure investments that were either not at a sufficient level of technical readiness (e.g., minirhizotrons) or outdated (e.g., continental maps of specific data products)—even though there may be sufficient scientific interest to merit further investment in the future. Moreover, NSF and NEON view the current infrastructure as a backbone to which other scientific infrastructure may be proposed for addition in the future during the operations phase. While some

of the NEON scope has been removed, we encourage the community to advocate and seek support to add these capabilities and others back into the NEON facility after operational status has been successfully achieved. The principal process to pursue this is through a mechanism called "assignable assets" and will be further described in greater detail on NEON webpages and at society meetings later this year.

New engagement strategy

Concerted changes are now being implemented to facilitate broader and stronger engagement of NEON with the scientific community. We at NEON view our success by how well the community utilizes our data and works with us to advance the future of continental-scale macrosystems ecology. We perceive the program's needs and the community needs as intrinsically linked.

Internal needs

The National Ecological Observatory Network needs the community to advise on the programmatic direction of NEON in order to maintain and provide the highest scientific rigor in this frontier science, as well as inform and provide input on designs, data product algorithms, best community practices, protocols, etc. NEON had originally pursued this through the STEAC and Technical Working Groups (TWGs, www.neonscience.org/science-design/community-input), which met with limited success. The STEAC was originally crafted to interface with the National Science Board (NSB) and others, and to broadly advise on the science before and during construction. Because construction is well underway, we have determined that the role of the STEAC has also changed with greater need to advise on the challenges of operations and the need to more broadly engage with stakeholder communities. As such, the STEAC is currently being reformulated to not only address these needs, but also, with substantial changes to NEON's organizational structure, to ensure the advisory input reaches its target. Similarly, the role of our TWGs is also being reformulated to foster more input from the community and refocused to help inform our operational model.

There will be a continuing need to optimize use of the operations budget and, at the same time, provide more impactful ways of engaging the research and educational communities. One of the guiding principles for the construction of NEON was to design infrastructure that minimizes operational costs. This principle is tangible when designing automated instrumentation, but currently there is no practicable replacement for human-based observations such as bird counts, litterfall collection, mammal trapping. Hence, a large fraction of operational costs is provided to support field technicians distributed around the country. An alternative is to "outsource" this function to universities, which would also serve to support other goals (i.e., education, building a new cohort of users inherently familiar with NEON data, and more broadly distributing R&RA funds). We continue to explore these and other types of programmatic changes to optimize resources and engage the stakeholder communities in new ways.

External needs

The National Ecological Observatory Network's previous ability to engage and communicate outward from headquarters has always exceeded its capacity. NEON is large and complex and provides many avenues to explore frontier science. Going forward, we will engage with the current and new stakeholder communities through several avenues. We will continue to have a presence at society meetings, ad hoc work-

shops, and advisory boards, as well as continue our undergraduate internship program and citizen science efforts. We will attempt to expand postdoctoral and visiting scientist positions in the NEON program. We will also encourage our scientists to continue to work collaboratively with faculty, students, and external Principal Investigators (PIs) to codevelop observatory science and participate in new leading-edge science.

Perhaps known to only a few individuals, NEON designs were codeveloped with a suite of national and international programs, and our success will be partially contingent upon ongoing codevelopment to advance our sphere of influence. For example, the NEON approach to aerosol optic depth was designed with the National Aeronautics and Space Administration's AERONET, nitrogen deposition with the National Atmospheric Deposition Program, eddy covariance standards with the World Meteorological Organization, and best practices for sampling soil microbial diversity with the Global Biodiversity Information Facility's Darwin Core, etc. Also NEON facilities have been colocated with the National Oceanic and Atmospheric Administration's Climate Reference Network, US Department of Energy AmeriFlux, NSF Long Term Ecological Research Network, the US Department of Agriculture Long Term Agroecosystem Research Network sites, and others.

The National Ecological Observatory Network has capabilities that can be requested by PIs to augment and integrate their studies into NEON's infrastructure (either physical or informational). These capabilities include use of a remote sensing platform or a mobile deployment platform or adding instrumentation or protocols to the current design (more descriptions can be found at www.neonscience.org/science-design). Development of the merit and feasibility review process for these "assignable assets" is underway, and we anticipate announcing this process in the near future. The "take home" point is that NEON has an integrated dynamic means to provide new PI-requested facilities to the stakeholder community that we expect will have high impact.

The National Ecological Observatory Network is designed to enable ecological forecasting. Frontier science and synthesis activities truly must originate within the stakeholder communities, and NSF has designed a funding mechanism to support such endeavors (program solicitation NSF 16-521). We look forward to working more effectively with stakeholder communities to advance these efforts in the coming years.

Cultural change

In the business world, culture overrides strategy (Coffman and Sorenson 2013), but few acknowledge its role in "big science." Unfortunately, NEON's past inability to effectively engage scientists resulted in an apparent divide between those "inside" and those "outside" NEON's approach and philosophy (Loescher et al. 2016). The new NEON leadership is actively removing previous barriers to establish effective engagement and making calls to the community to work with us. We recognize that this may not happen overnight, but the scientific imperative to advance the field of ecology for societal benefit is far too great for past cultural legacies to impede progress.

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